

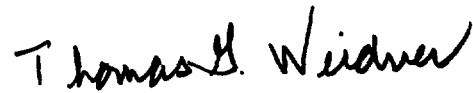
A Study of Augmented Soft Tissue Mobilization

An Honors Thesis (HONRS 499)

by

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A handwritten signature in black ink that reads "Thomas G. Weidner". The signature is written in a cursive style with a large, stylized 'T' and 'W'.

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Purpose of Thesis

Ball Memorial Hospital along with Central Indiana Sports Medicine Clinic are developing and research a new soft tissue treatment. The purpose of this paper is to give a better understanding of why Augmented Soft Tissue Mobilization (ASTM) may be so successful through discussion of the inflammation and healing process, traditional forms of treatment, such as transverse friction massage and the rationale behind ASTM. The body responds immediately to trauma at the time of an injury. This basic response is the inflammatory response. Out of this response, the body lays down scar to reinforce damaged areas. Scar can often be painful and hinder normal function. Treatments of scar have included massage. Based on known theories of how the body responds to stress applied to soft tissue, arises the rationale for ASTM. Since ASTM is still being researched, it should be viewed as aiding traditional forms of treatment, not replacing them.

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The most frustrating event for an active person is a persistent or recurring injury. In the past, after conventional forms of physical therapy have been unsuccessful surgery was the only option. Ball Memorial Hospital along with Central Indiana Sports Medicine Clinic in Muncie, Indiana are developing and researching a new non-invasive technique called Augmented Soft Tissue Mobilization (ASTM). The purpose of this paper is to give a better understanding of why ASTM may be so successful through discussion of the inflammation and healing process, traditional forms of treatment, such as transverse friction massage, and the rationale behind ASTM.

The body responds immediately to the trauma at the time of an injury. The basic response that the body undergoes following injury is referred to as the acute inflammatory response (Arnheim, 1989). The main goal of inflammation as defined by James Booher and Gary Thibodeau (1994) is to "localize the extent of injury, to rid the body as a whole and the injury site of waste products resulting from initial trauma and...to enhance healing" (p. 120). This process occurs in three phases, the acute response, the repair and regeneration phase, and the remodeling and maturation phase (Booher and Thibodeau, 1994). Since these stages overlap, it is difficult to detect when the process moves from one stage to the next.

The acute inflammatory response begins immediately after the injury and lasts approximately three to four days (Arnheim 1989). Daniel Arnheim discusses this response in great depth. Acute

inflammation can be detected by heat, redness, swelling or pain on or around the injury site, or by a loss of function. At the time of the injury, the blood vessels undergo vasoconstriction. Vasoconstriction lasts for up to ten minutes. During vasoconstriction, vessels that were broken at the time of the injury begin to heal through coagulation. The vessels begin to allow blood to enter the injured area by slowly enlarging, or vasodilating. This allows exudate, which is a high protein fluid that contains cellular debris that arose from damaged blood vessels and tissue, to collect at the injury site. This collection of exudate and blood is the cause of swelling. During the acute inflammatory response, margination also takes place. Margination is the process of leukocytes lining up and adhering to the endothelial wall of the injury site.

On the cellular level, during the acute inflammation phase, mast cells, which are connective tissue cells, and leukocytes accumulate at the injury site in great number. Mast cells contain heparin, which is a blood anticoagulant and histamine which produces arterial dilation and capillary permeability. Capillary permeability means that the vessel wall allows more substances to pass through than it does under normal circumstances. This process allows the capillary to rid itself of damaged cells and extra protein. The function of the leukocytes is to bring the anticoagulant substances to the damaged or inflamed areas. Smaller leukocytes called neutrophils ingest cellular debris and bacteria through a process called phagocytosis (Booher and Thibodeau 1994). The amount of exudate

depends greatly on the amount of damage to the blood vessels and the permeability of the non-damaged cells (Arnheim 1989).

Phase two of the inflammatory response is the repair and regenerative stage. This phase is healing and restoration of damaged tissue. The phase begins approximately 48 to 72 hours post injury and can last up to six weeks (Arnheim 1989). Repair and regeneration begins when the cellular debris has been completely removed and a clot has been established (Arnheim 1989).

During repair, two types of healing are taking place. The first type is primary healing, which occurs in an injury that has even edges that are in close approximation to one another (Arnheim 1989). An example of primary healing is an incision. The other type of healing is secondary healing which occurs when there is large amounts of tissue damage or loss. This tissue is replaced by scar tissue (Arnheim 1989).

With the exception of the epidermis and bone, most tissues can not regenerate their specialized cells (Booher and Thibodeau 1994). Once damaged, the specialized cells are replaced by scar tissue. Formation of scar is quite common after any type of trauma. However, athletic trainer Daniel Arnheim (1989) states "because scar tissue is less viable than normal tissue, the less scarring the better (p. 233)." A scar is a firm, fibrous, inelastic tissue that does not contain any capillaries (Arnheim 1989). If left alone, scar tissue can complicate healing by compromising the joint and its function. Due to the randomness and the three dimensional nature of scar formation, scar tissue

acts as a glue that prevents normal gliding of tissue fibers over one another. Scar tissue begins the healing process through the exudate. From the exudate a mass called granulation tissue begins to form (Arnheim 1989). Granulation tissue is highly vascularized. In primary healing, the development of granulation tissue is kept to a minimum (Arnheim 1989). Immature connective tissue cells called fibroblasts and endothelial cells begin to collect in this granulation tissue (Arnheim 1989). From the fibroblasts develops a protein substance called collagen. Collagen begins to form a loose lattice work of randomly arranged fibers which initially is very fragile and very vascular (Starkey 1993). This lattice work gradually thickens by forming cross links with other collagen fibers, strengthening the lattice work (Booher and Thibodeau 1994). The network of fibers becomes a more organized pattern (Booher and Thibodeau 1994). Scar formation is identical in all tissues (Booher and Thibodeau 1994).

During regeneration, damaged or dead capillaries are replaced. Before this can occur, cellular debris must be completely eliminated, endothelial cells must be regenerated and fibroblasts must be produced (Arnheim 1989). When a vessel is injured, it is normally deprived of oxygen, which leads to death. This lack of oxygen stimulates the growth of new capillaries which grow in the walls of intact vessels. These capillaries connect with other vessels and mature. As they mature, more oxygen is brought into the area which stimulates growth and healing (Arnheim 1989).

The third phase of inflammation is the remodeling phase. During this phase scar tissue continues to strengthen from approximately three months post injury to one year post injury (Arnheim 1989). Scar tissue begins to become avascular during this phase (Booher and Thibodeau 1994). The tensile strength and the final appearance of the scar depends on the amount of stress placed upon it (Booher and Thibodeau 1994). It is at this point where Wolf's law and Davies' law become important. Wolf's law states that tissue adapts to stress placed on it by increasing its strength along the area of applied stress. Davies' law states that soft tissue will remodel to the stress that is placed upon it by adapting so that it can better withstand those stresses (Davies 1983). Another law that parallels Wolf's law is the SAID principle, or specific adaptations to imposed demands. These adaptations are predictable. The therapist should take full advantage of this knowledge in treating. In a presentation at Ball Memorial Hospital, Dr. Thomas Sevier states "If stressed in a proper fashion, the body will adapt by modifying its structure, shape and functional abilities to meet demands placed on it."

Occasionally during acute inflammation, calcification will occur in soft tissue. These calcification usually are self limiting and will disappear when symptoms go away (Leadbetter 1990). In some cases, the injury can not heal completely during the acute inflammatory response. If no resolution occurs after one month, the injury is considered chronic (Arnheim 1989). A chronic inflammation transpires from repeated trauma or from

overuse (Arnheim 1989). Teitz (1989) states that "overuse injuries...are caused by relatively low loads, which are applied so frequently that normal adaptive processes occur" (p. 299). With chronic inflammation, one major symptom is the loss of function (Starkey 1993). This loss of function is caused by large amounts of collagen laid down in the injured area in the body's attempt to finalize the healing process by continually undergoing fibroblastic activity (Starkey 1993). Most chronic inflammations are considered tendinitis, however, this may not be the most accurate title. Tendinosis may be more accurate. Tendinitis occurs during the inflammatory stage and possess hypercellular activity. Tendinosis is a chronic condition. The tendon is degenerative and atrophies. If a biopsy is performed, there would be no sign of inflammation, since inflammation only lasts 72 hours. The collagen in the fibers is degenerating. There is hypocellular activity. Traditional treatments for tendinitis, such as rest and anti-inflammatory medications, do not work for tendinosis.

Traditional forms of treatment of healing and scar tissue formation have included some form of massage. Massage is one of the oldest techniques of treatment and dates back to at least the ancient Olympics (Starkey 1993). William Prentice (1990) defines massage as "a mechanical stimulation of the tissue by means of rhythmically applied pressure and stretching" (p. 258). The physiological effects of massage are similar to that of the inflammatory response in that massage increases local blood flow and releases histamines (Starkey 1993). Massage also has an

effect on scar tissue. Massage stretches and breaks down adhesions between the skin and subcutaneous tissue as well as stretching the adhered tissue (Prentice 1990). James Cyriax introduced the most common form of massage used in sports medicine is transverse or cross friction (Keesler & Hartling 1983). Cross friction massage is concentrated over a smaller area than a general massage and can focus more on ligaments and tendons as well as muscles (Prentice 1990). It is performed with the fingers, usually with the thumb or index finger, and pressure is applied perpendicularly to the fibers (Prentice 1990). Treatment lasts for approximately 7 to 10 minutes (Prentice 1990). In addition to loosening adhesions and softening scar tissue, cross friction massage also helps with the absorption of edema (Prentice 1990). Cross friction massage softens inflammation and helps the body to break down the inflammation and prevent excess scarring and adhesions (Prentice 1990). William Prentice states that "in chronic inflammation...[the] inflammatory process 'gets stuck' and never really accomplishes what it is supposed to" (p. 270). The purpose of cross friction massage is to increase the inflammation to a point where the inflammatory process can complete itself (Prentice 1990).

The concept of creating an inflammation is the basic concept for Augmented Soft Tissue Mobilization (ASTM). As defined by Ball Memorial Hospital (1995), "ASTM is an advanced form of soft tissue mobilization which enables physical therapists to efficiently breakdown scar tissue, soft tissue adhesions and fascial restrictions." ASTM is a controlled microtrauma that

creates a localized inflammatory response (Stover et al, 1996). This stimulates the remodeling phase and repair to the damaged area. ASTM utilizes three specially designed instruments. By using instruments the therapist is able to cover more surface area and create more microtrauma with less effort (Stover et al, 1996). Due to the rigid surface of the instruments, the therapist can apply more pressure per square millimeter and maintain constant pressure, as well as alleviating stress on the therapists joints (Sevier, 1995). The soft tissue of the therapists hands and thumbs disperse the pressure where the ASTM tools keep pressure in a concentrated area. The utilization of the instruments allows the therapist to feel the texture of the tissue being treated and allows the therapist to detect areas of scar tissue.

According to Ball Memorial Hospital, an appropriate candidate for ASTM is "any condition which may have as its primary or contributory cause: soft tissue fibrosis, adhesion or scarring be it from surgery, acute trauma, biomechanical overload, or accumulative microtrauma. Also acute or chronic inflammatory conditions such as tendinitis or tendinosis (Stover, et al 1996)." The only contraindications identified at this point are infections or blood disorders such as hemophilia. The therapist should take a few precautions when assessing appropriateness of a candidate. Patients with any form of a malignancy, patients taking blood thinners, or diabetics should consult their physician before beginning ASTM treatment. Growth plates in children and adolescents should be treated very

carefully so as not to disturb the growth plate. Post operative incisions should be treated gently due to tenderness. Patients who bruise easily should also be treated gently to minimize their discomfort and the amount of bruising. Open wounds should not be treated to avoid contamination of the treatment tools as well as to avoid infecting the wound. Patients who are squeamish may need to be treated lying down to prevent fainting. A final precaution for the therapist is surgical hardware. Direct pressure of the ASTM instruments on any type of surgical hardware such as screws, pins or plates may be extremely painful and intolerable to the patient. The patient's comfort should always be considered. To accomplish this, the therapist should maintain good communication with the patient and adjust the treatment accordingly.

Once Augmented Soft Tissue Mobilization has been suggested and the patient has received a physician's referral, the patient is first evaluated by the physical therapist. This initial evaluation investigates the patient's severity by looking at pain intensity at rest, pain intensity with activity, duration of pain and frequency, and lifestyle impairment. Pain is measured on a scale of zero to ten with zero as no pain and ten as unbearable pain. Previous medical history is also taken into consideration. Measurements of flexibility, range of motion, strength and function will also be taken. Biomechanics of the area and adjoining areas will be assessed. This baseline data will allow for future comparison and eventual generation of outcome data. Discussion with the patient of what scar tissue and fibrosis are

along with discussion of the rationale behind ASTM and what the patient should expect are all helpful in not only preparing the patient but also in increasing compliance. The treatment begins with an active warm-up to prepare the area for the upcoming workout, followed by a stretching program. The importance of stretching should be emphasized to the patient. Stretching allows the body to properly respond to stress and allows scar tissue to be laid down in a controlled manner. ASTM is then performed to identify areas of fibrosis. Following ASTM, the stretching program is repeated. A home stretching program is also implemented. Resulting from Davies' law of soft tissue, it is believed that stretching is the most crucial part in the success of ASTM because it realigns the random fibers of scar tissue to the direction of the muscle fiber. Future visits will begin with an active warm up, followed by stretching, ASTM, strengthening, stretching and ice. As the patient improves, strengthening will progress from generalized activities to functional activities. Theoretically, by gradually subjecting tissues to more challenging stresses, the alignment pattern of new connective tissue during the remodeling phase of tissue repair is influenced.

Other areas of patient education include what the patient can expect to experience. As mentioned earlier, one such item is possible squeamishness. Squeamishness can be contributed to few factors such as the patient's personality, too much pressure over a sensitive area or possibly due to a release of toxins from the injury site. Since ASTM is providing a controlled microtrauma,

bruising is common. While bruising is not the goal of the therapist, people who do sustain a certain amount of bruising appear to respond better and quicker to treatment. The patient can also expect peaks and valleys in treatment. Sometimes the injury appears to get worse before it gets better. It is following these "low" times that the patient will rapidly progress. Stretching during these valleys is still very important. Patients may also experience a "break-out" where there is a systemic fatigue or malaise. This maybe caused by a large turnover of connective tissue along with a release of toxins or metabolites. Large improvements usually follow. This phenomenon appears to be more common in athletes, because they are more likely to highly stress the treated area and thereby increasing metabolism and tissue turnover. The scar tissue that is broken down is reabsorbed into the body and either recycled or eliminated.

Analyzing and correcting biomechanics of the involved area and the adjoining areas is very important. When the body is involved in a repetitive activity, over time the muscles that are utilized more become stronger and the less utilized muscles become weaker in comparison. This creates muscular imbalance. The body requires balance and when it becomes unbalanced the body compensates. This compensation changes the patterns of muscle usage. At the same time, the body is trying to reinforce weaker areas by laying down scar tissue. As layer upon layer of scar tissue is laid down, the patient begins to notice pain and loss of function. As the symptoms worsen, the body continues to

compensate, which eventually compromises the entire kinetic chain. The chain is only as strong as its weakest link. Stover et al (1995) state "Therefore, any abnormalities, weaknesses, or changes in function in one particular portion or link of the chain will affect the ability of the rest of the extremity to function (4)." Detecting and correcting any abnormalities in biomechanics aid not only in the treatment of the injury but also in preventing recurrence.

Among the injuries that ASTM has been highly successful in treating include lateral epicondylitis, carpal tunnel syndrome, anterior knee pain and shin splints. Two case studies are discussed in the appendices.

ASTM has many advantages over other forms of treatment. It allows the patient to continue to work or practice during the course of the treatment. ASTM reduces the need for splints or braces. ASTM has been successful when other forms of traditional treatment methods have failed and thus has lessened the need for surgical intervention. ASTM encourages faster rehabilitation and recovery, which in turn encourages a quicker return to work or competition and usually the return is at a higher level of function. ASTM requires fewer physical therapy visits than traditional methods and lowers the cost of treatment. Through the development of an individualized stretching program and functional progressive strengthening program, recurrence of the scar tissue is minimal.

With healing, whether acute or chronic, age, general health and nutrition play a big role (Arnheim 1989). These factors

should be taken into consideration regardless of the form of treatment. Another factor that should be taken into consideration is continued use of the injured area during the acute inflammation period (the first 72 hours post injury) will continue the damage and prolong the inflammation process (Teitz 1989).

All research done on Augmented Soft Tissue Mobilization at this point has been done in a clinic and based on theories and patient feedback. No laboratory research has yet been done to verify what is believed to be happening in the healing process with ASTM. Although it appears to be successful, Augmented Soft Tissue Mobilization should only be viewed as enhancing traditional methods of treatment, not replacing them.

APPENDIX 1
ASTM Case Study

History: The patient is a 74 year old white woman with a diagnosis of arthrofibrosis of the right knee five months post total knee replacement. Prior to the knee replacement she experienced several years with of severe pain to the point of nonambulation. She was kept in the hospital following the knee replacement for 12 days due to extreme pain and gait dysfunctions. Her doctor referred her to physical therapy and specifically requested ASTM.

Evaluation: The initial evaluation showed an antalgic gait with reduced time in single leg stance on the right lower extremity. Range of motion was flexion 70 and extension 15.

Treatment: She was to receive therapy two times a week for four weeks for a total of eight treatments. She received moist heat with the knee in extension, followed by ASTM to the anterior and posterior aspects of the knee, the IT band, and the lateral iliac crest. Her exercise program included a warm up recumbent biking, step ups, lateral stepping against Theraband resistance, calf raises and backwards walking. Her stretching regimen included hamstrings, quadriceps, gastrocnemius and soleus, and IT band. The stretches were performed following the biking warmup and repeated following exercises. Cryotherapy was applied to the anterior and posterior of the knee in extension completing each therapy.

Results: By the fourth visit, the patient reported a 50% improvement, pain at rest recorded at 0/10 and 4/10 with activity. Pain medication was required only occasionally at night. Range of motion had increased to 83 flexion and 5

extension (23 increase in total range of motion.)

She was discharged after the eighth visit with a recorded pain level of 0/10 at rest and 4/10 with activity. Active range of motion was recorded at 94 flexion and 1 extension. No pain medications were needed. She no longer had an antalgic gait but still had slight extensor lag of the right knee.

APPENDIX 2
ASTM Case Study

History: The patient was a 20 year old male football offensive guard that played for a Division III school. His symptoms began April 15, 1994. He had a history of chronic right ankle sprains dating back to high school. Evaluation notes pain, decreased range of motion, pain recorded at 6/10 with activity and significant pain with popping and grinding of the ankle. Previous to arrival at Central Indiana Sports Medicine Clinic the patient began having problems in December 1989 when playing a pick-up game of basketball. He inverted his right ankle when landing from a jump. He experienced immediate pain and swelling. Initial x-rays were negative. An orthopedic evaluation noted bone fragments from the tibia. Arthroscopic surgery was performed January 1990 to remove these fragments. He completed five weeks of successful physical therapy with no pain and full range of motion. He successfully completed his first year of college football with no ankle problems. In the fall of 1991 he began experiencing pain with popping and grinding of the ankle. He had decreased range of motion. His symptoms worsened over time. Halfway through the season, he was unable to complete practices due to pain. An orthopedic evaluation noted bone fragments and arthritic changes. He went through another rehabilitation program and began taking non steroidal anti-inflammatory medications. In the fall of 1992, his pain increased, the popping and grinding worsened and the ankle joint began to lock. He was unable to finish the last six weeks of the football season due to a spiral fracture of the distal left fibula. In December 1993 osteophytes were removed and scar

tissue resection was surgically performed. He spent four weeks in physical therapy followed by a home rehabilitation program. He was discharged from physical therapy with 80% improvement. He returns in April 1994 concerned about continued pain with activity, decreased range of motion, and the need for anti-inflammatory medication. He felt he was not getting any better.

Examination: He had a bulky 4 cm. immature surgical scar anteromedially. There was tenderness over the scar and over areas of palpable fibrotic connective tissue. There was significant thickening and adhesions of underlying soft tissue around both malleoli and anterior compartment of the lower leg and anterior aspect of the mortis with decreased range of motion.

Diagnosis:

1. Chronic right ankle pain
2. loss of function
3. decreased range of motion
4. fibrotic scar tissue surrounding right ankle

Treatment: The patient went to physical therapy twice a week for seven weeks. He received ASTM, active stretching, home flexibility program for gastrocnemius, soleus, ankle inversion, eversion, plantarflexion and great toe extension. Treatment was concluded with ten minutes of cryotherapy. He was re-evaluated every three weeks. A functional progression was also implemented including light plyometrics.

Results: MRI's dated at 5/2/94, 7/21/94, and 8/9/94 essentially showed the same readings with no changes in soft tissue. The following table compares range of motion measurements of the ankle, recorded pain with activity and medication required during treatment.

	5/2/94	5/16/94	5/26/94	6/28/94
dorsi- flexion	5	8	10	10
soleus flexion	10	14	12	18
plantar- flexion	35	40	36	47
eversion	15	21	20	26
inversion	20	33	40	42
pain with activity	6/10	4/10	3/10	0/10
NSAIDS	yes	yes	yes	no

Conclusion: ASTM successfully treated chronic right ankle pain and fibrosis after 5 months of conventional therapy failed to alleviate symptoms. Pain decreased from 6/10 to 0/10, range of motion increased and MRI testing did not show any changes in the soft tissue.

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